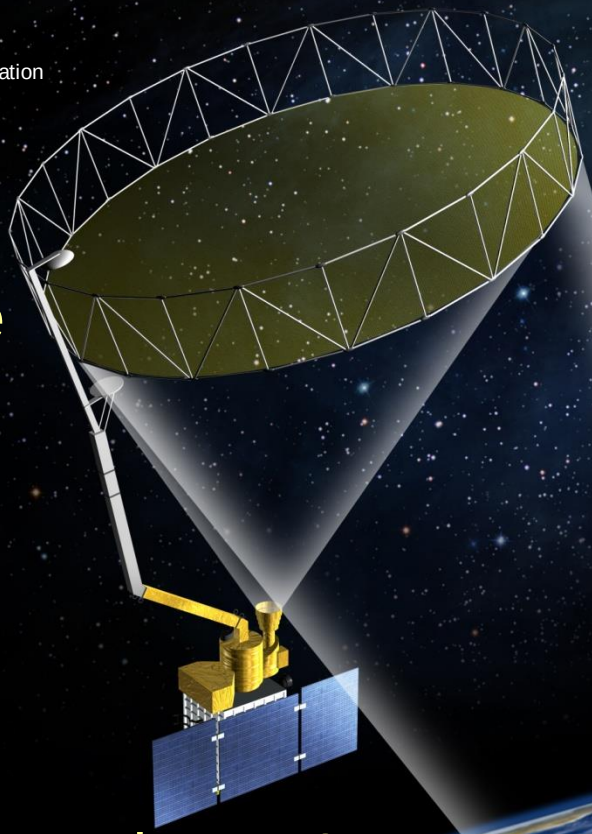
National Aeronautics and Space Administration



Soil Moisture Active Passive Mission

SMAP

Water-Body Correction for Land Brightness Temperature

Julian Chaubell, Simon Yueh (Jet Propulsion Laboratory, California Institute of Technology)

Science Team Meeting #10

October 17-18, 2017

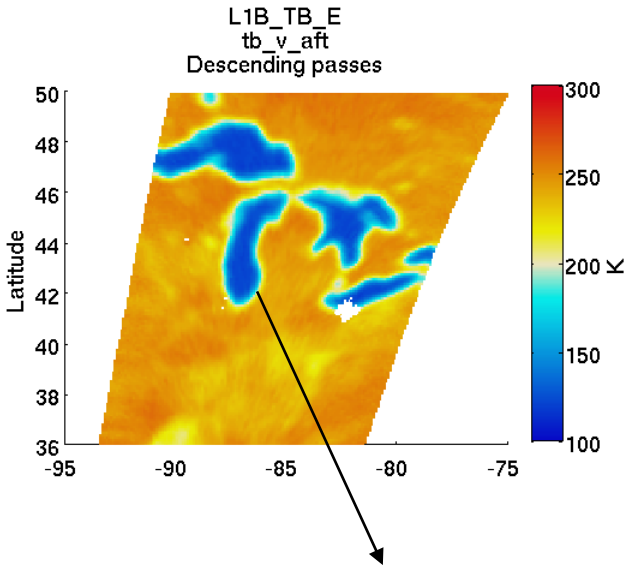
MIT, Cambridge

Outline

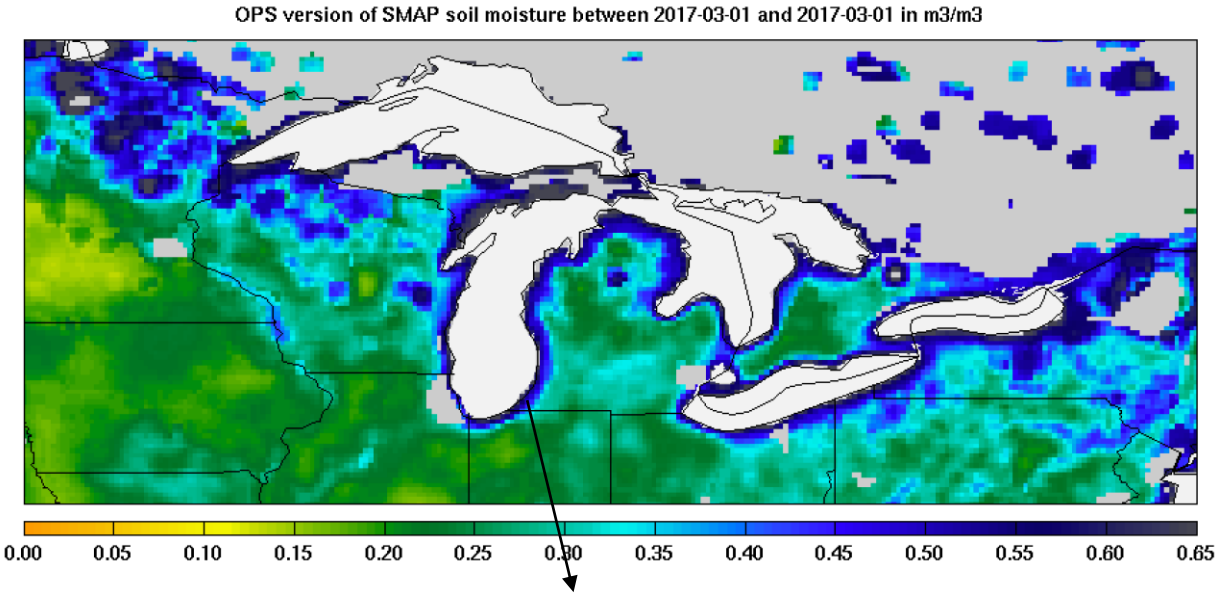
- Motivation
- Overview of the applied theory for L1B_TB product and L1B_TB_E
- Simulated examples and results
- Application to real data and results
- Product overview

Motivation

- SMAP radiometer footprints over land can cover water from open water bodies or near coastlines
- Emission by water integrated along with emission by land, leading to underestimated TB
- Underestimated TB leads to wet bias in soil moisture retrieval



Underestimated TB



Overestimated SM

Water Contamination Correction Implementation

The total measured temperature can be separated into two contributions:

$$TB_p = (1-f) * TB_p^{land} + f * TB_p^{water}$$

- If footprint is on land we apply the formula:

$$TB_p^{land} = \frac{TB_p - f * \overline{TB}_p^{water}}{1-f}$$

- If footprint is on water we apply the formula:

$$TB_p^{water} = \frac{TB_p - (1-f) * \overline{TB}_p^{land}}{f}$$

where *f* is the water fraction. *f*=1 in pure water and *f*=0 for pure land.

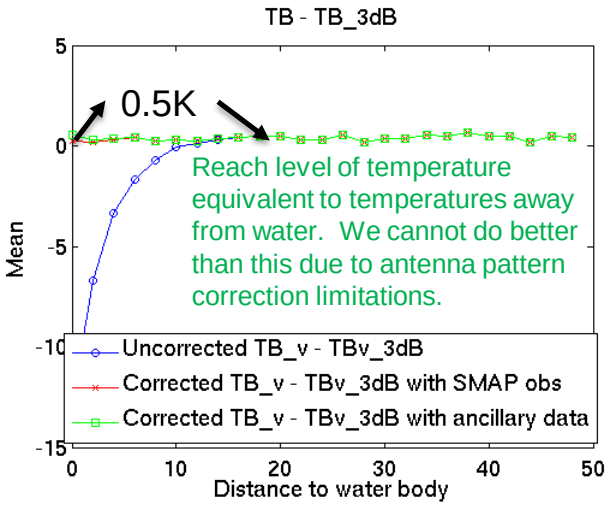
$$f = \int G.M d\Omega = \int_{\theta=[0,\pi],\psi=[0,2\pi]} G(\theta,\psi)\, M(\theta,\psi) \sin\theta \; d\theta d\psi$$

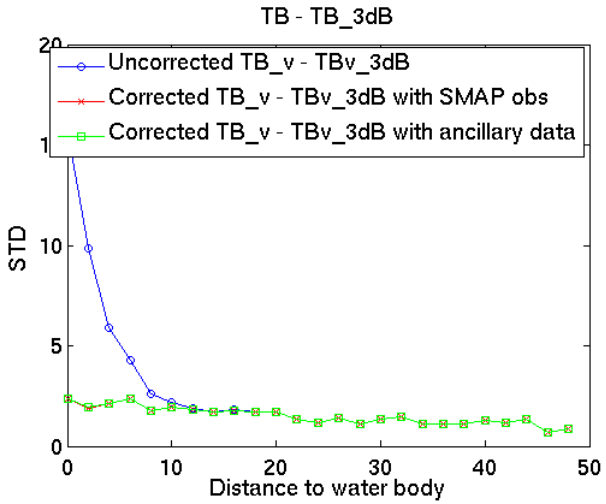
$$\cong \int_{\theta=[0,10*\pi/180],\psi=[0,2\pi]} G(\theta,\psi) M \sin\theta \; d\theta d\psi$$

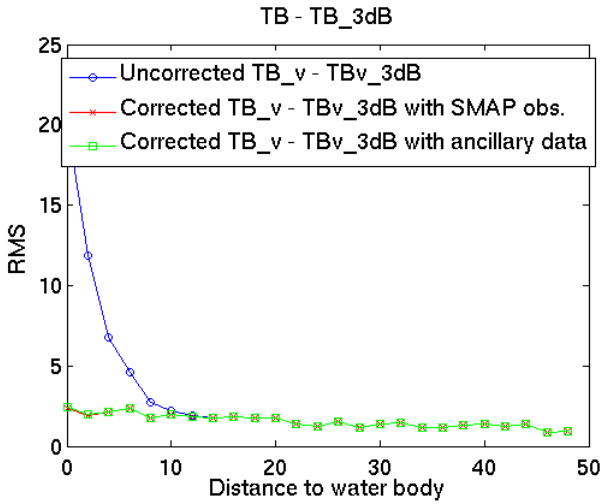
Implementation (continuation)

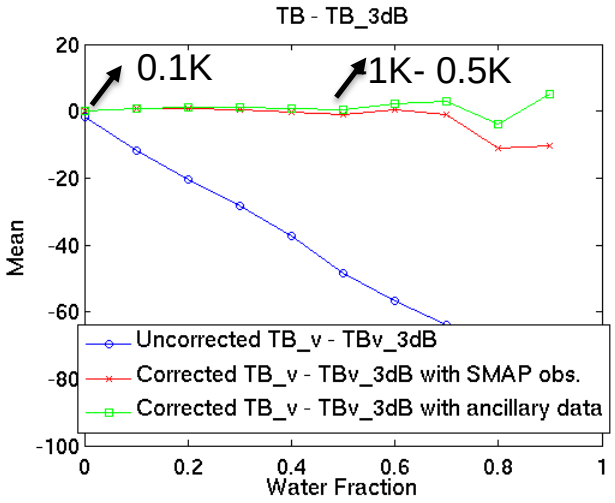
- M is the land mask defined over 1Km EASE2 grid.
- $\overline{TB}_p^{water}$ is an estimated TB over water bodies.
- $\overline{TB}_p^{land}$ is an estimated TB over land.
- The estimated TB can be obtained using SMAP observation free of contamination or using ancillary data.

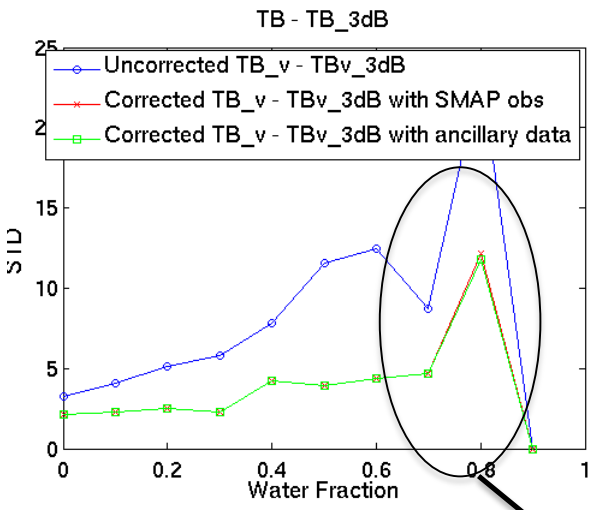
Statistics Based on Simulations – Great Lakes

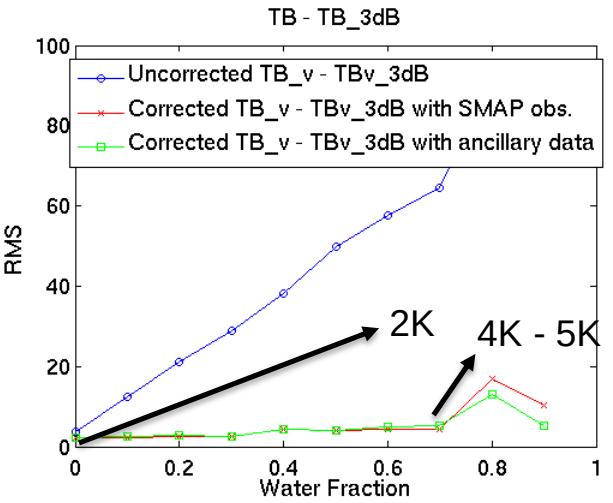








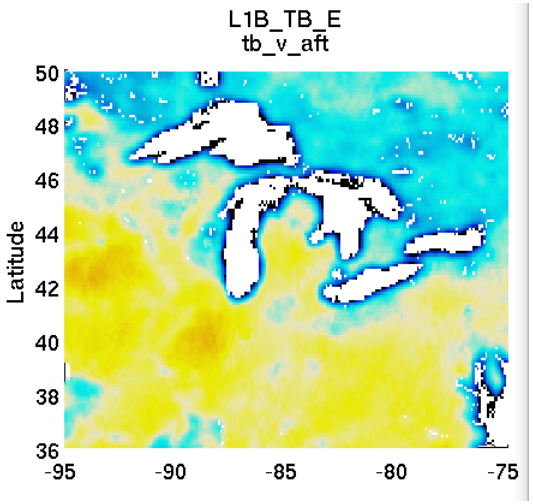




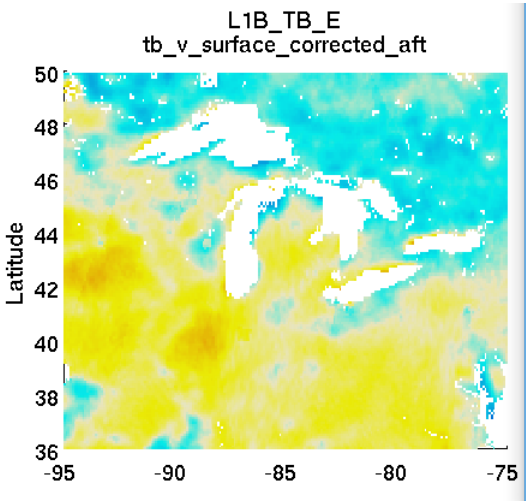
This area corresponds to small islands. No enough data for stats

Real Data

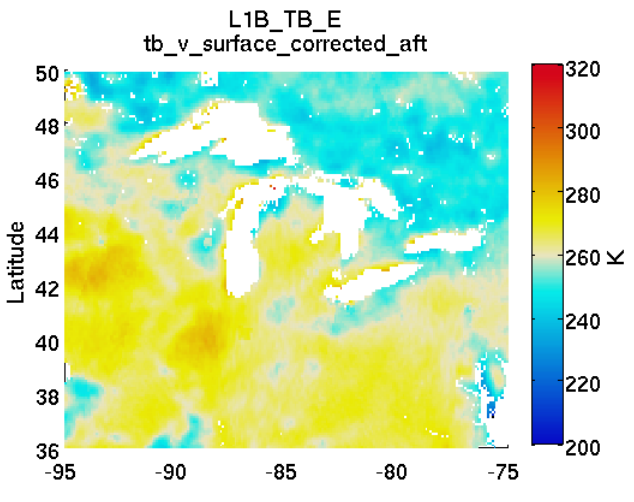
Uncorrected TB



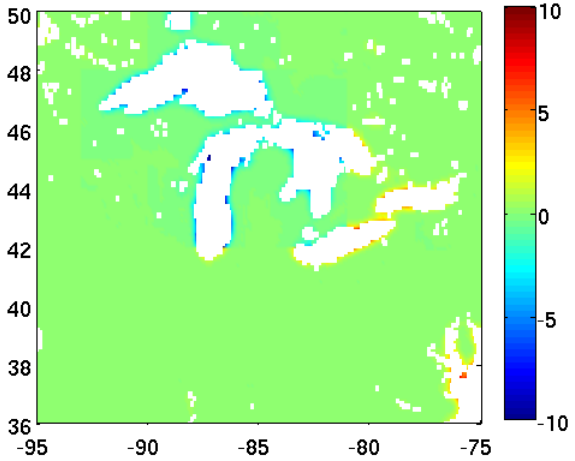
Corrected with SMAP obs.



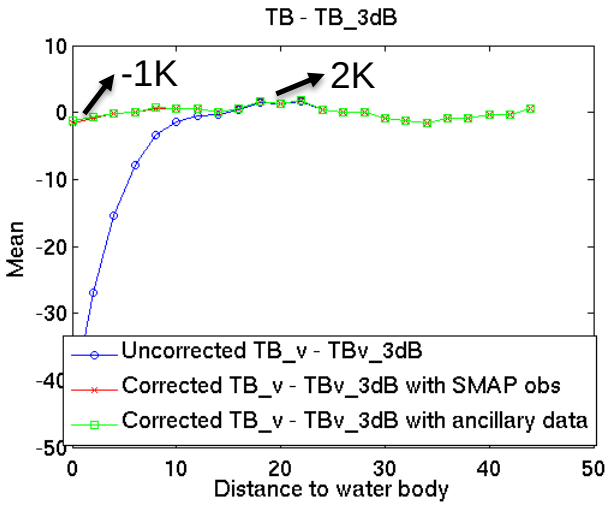
Corrected with ancillary data

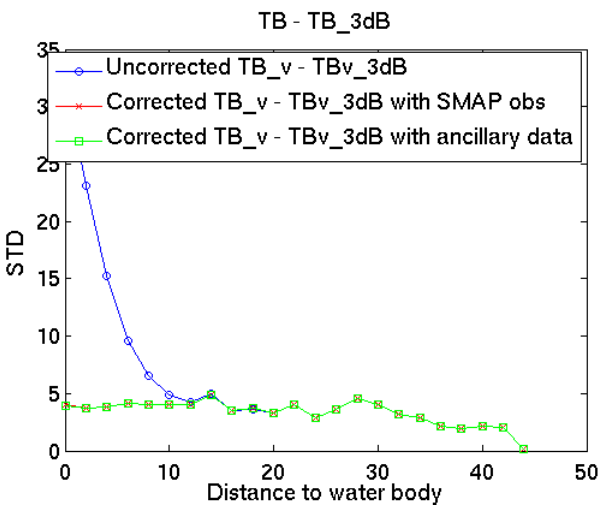


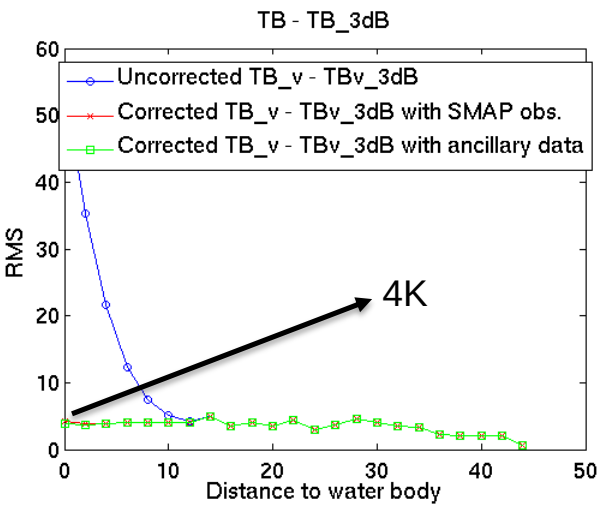
SMAP Obs. Correction – Ancillary data Correction

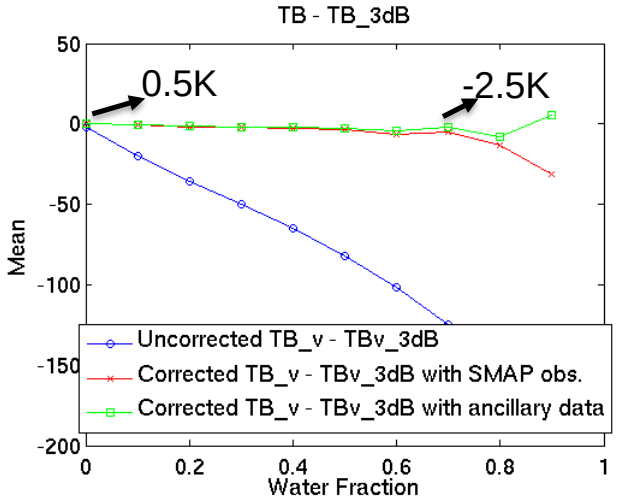


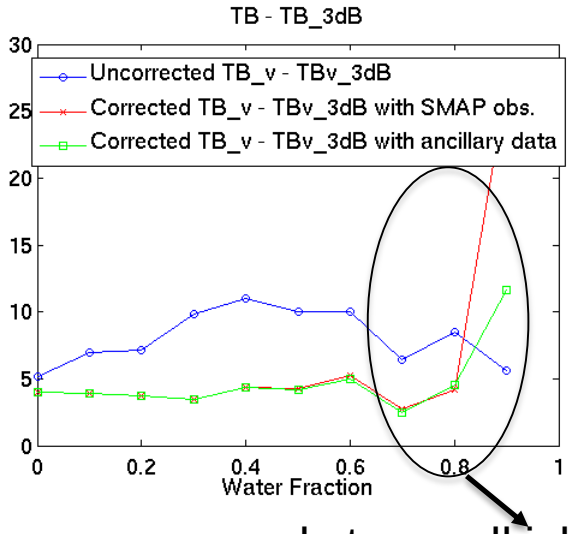
Statistics Based on Simulations – Yucatan

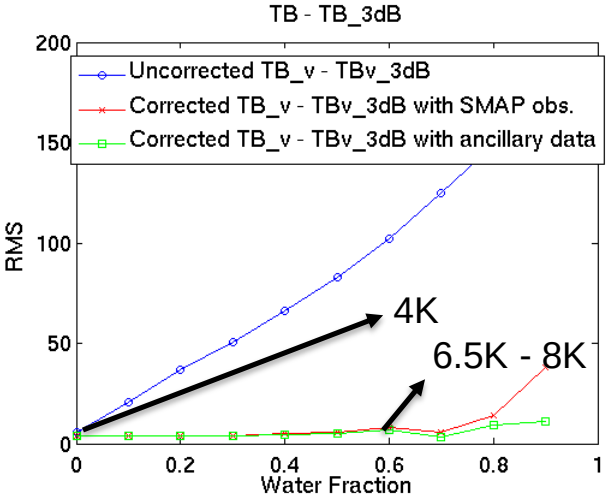








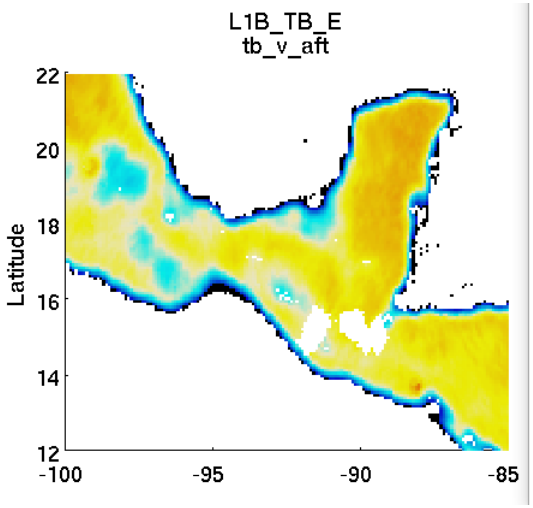




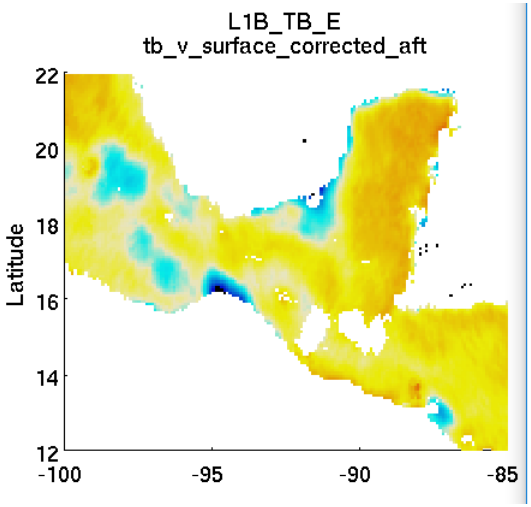
This area corresponds to small islands. No enough data for stats

Real Data

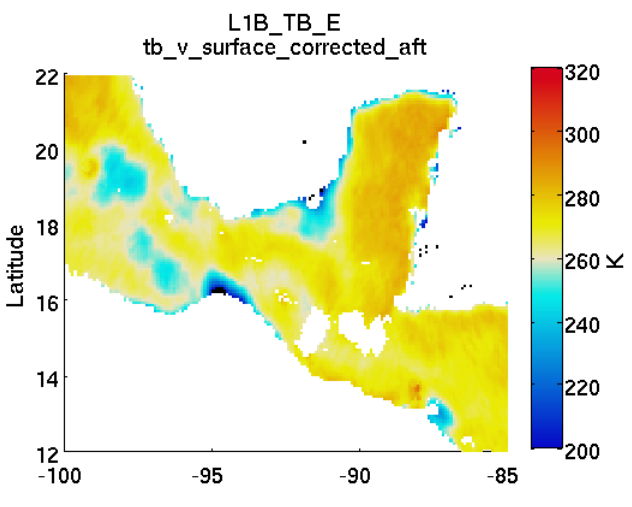
Uncorrected TB



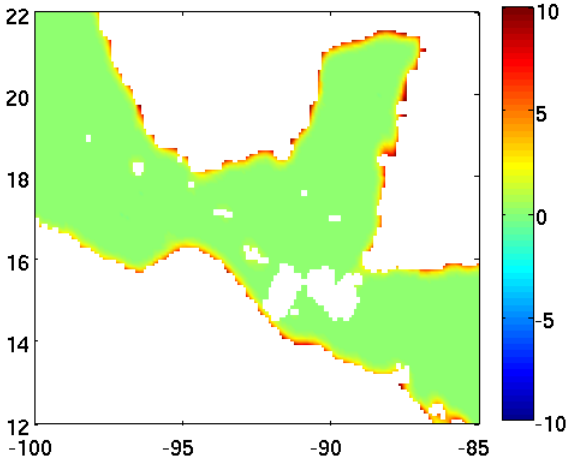
Corrected with SMAP obs.



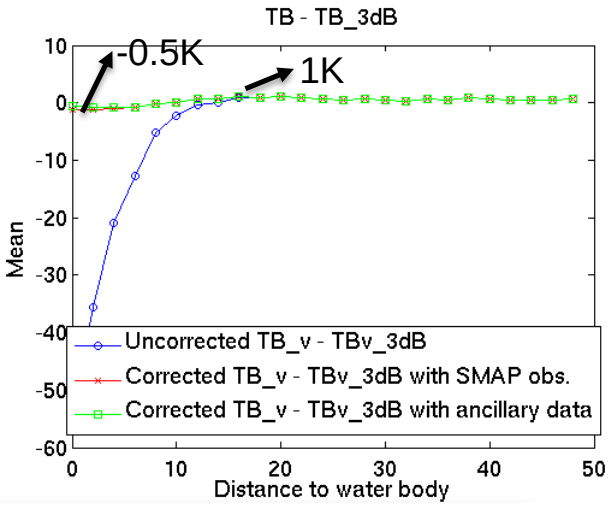
Corrected with ancillary data

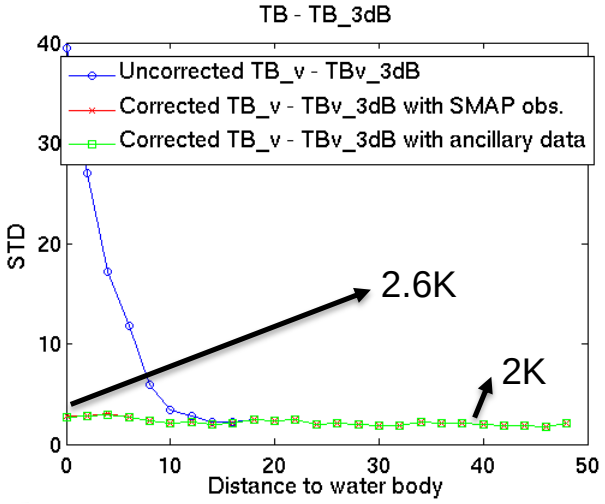


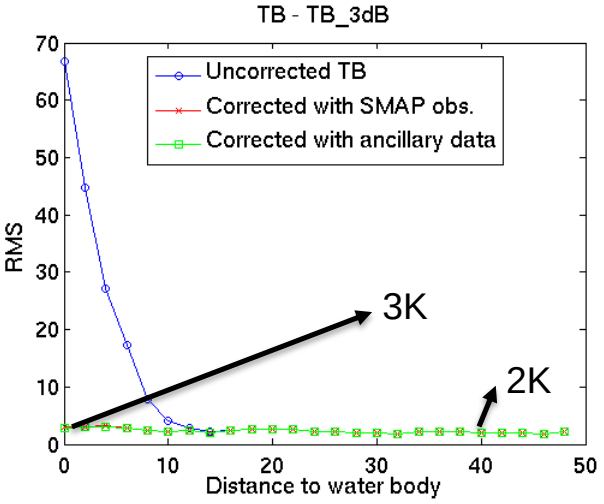
SMAP Obs. Correction – Ancillary data Correction

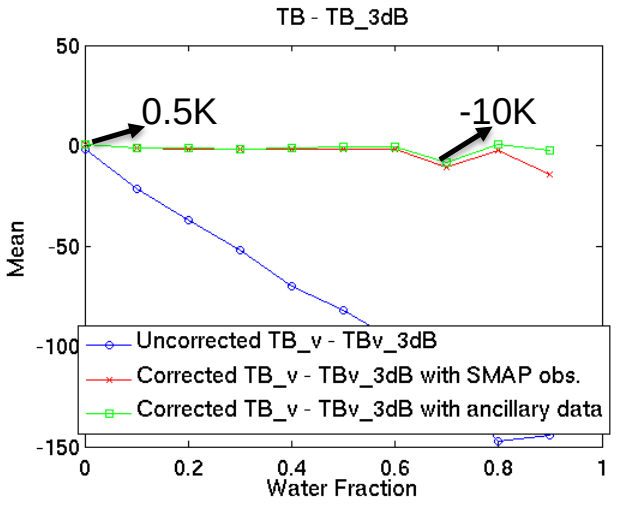


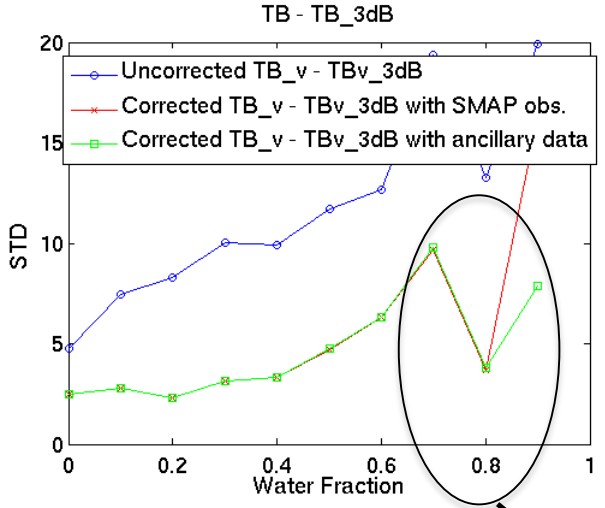
Statistics Based on Simulations – Madagascar

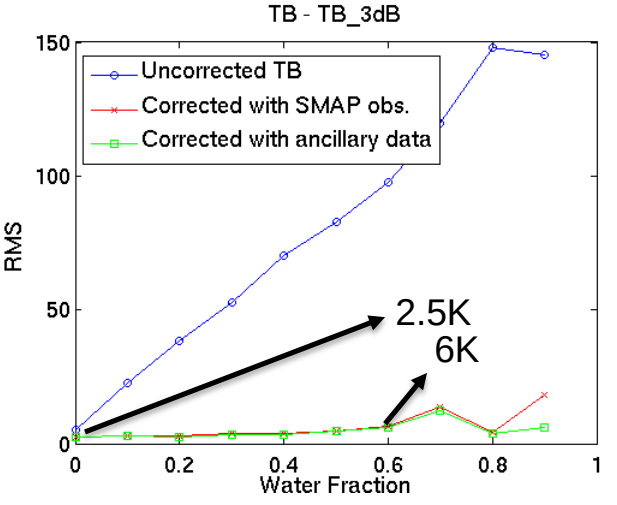








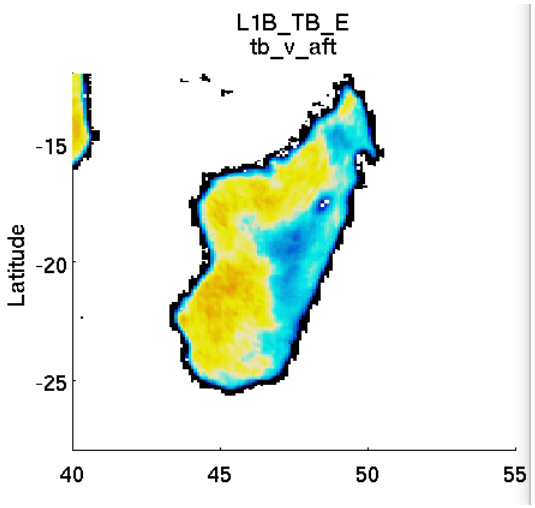




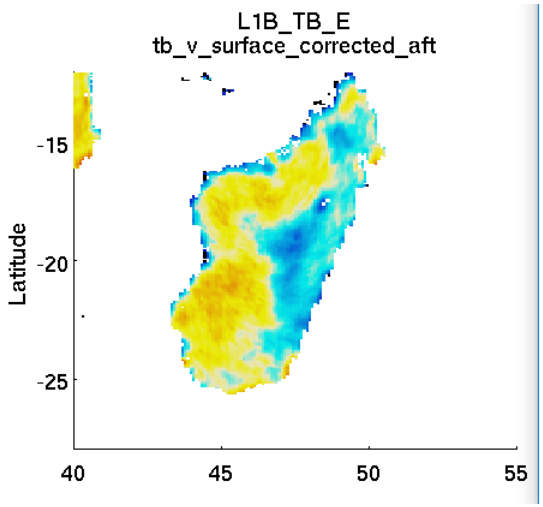
This area corresponds to small islands. No enough data for stats

Real Data

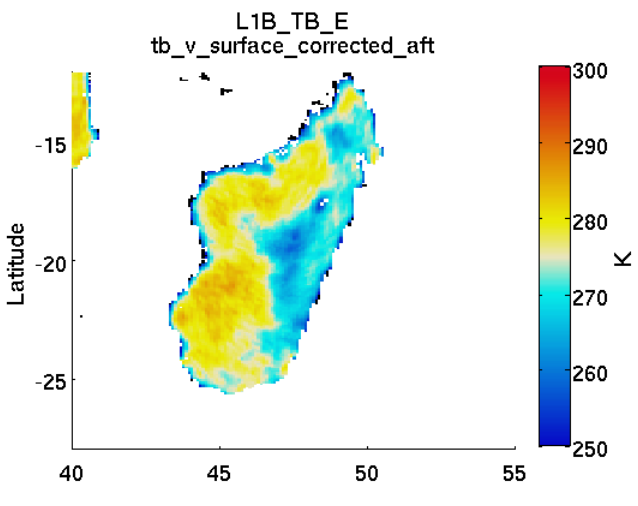
Uncorrected TB



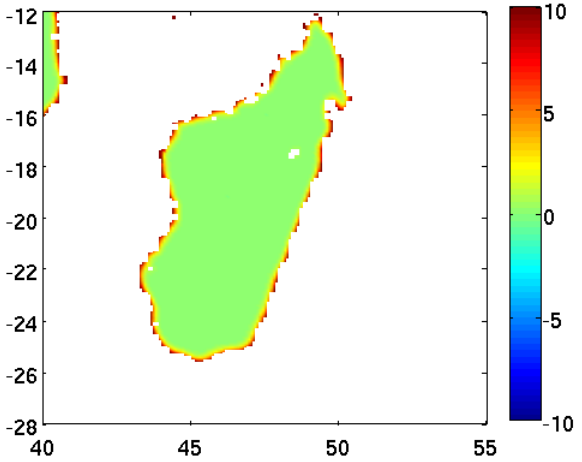
Corrected with SMAP obs.



Corrected with ancillary data



SMAP Obs. Correction – Ancillary data Correction



Over Water Bodies

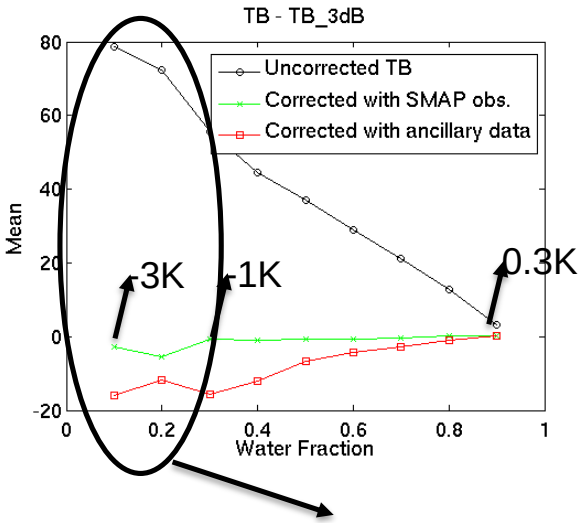
- Correction is vulnerable to the variation of selected TB.
- Depends on a good estimation of land TB.
- Land is often more inhomogeneous than water and TB over land therefore has a larger variance.
- In order to use a TB of small water fraction, the pixel needs to be away from the coast and thus may not well represent actual coastal TB land.
- A slightly different approach using SMAP observation is implemented for correction of water TB:

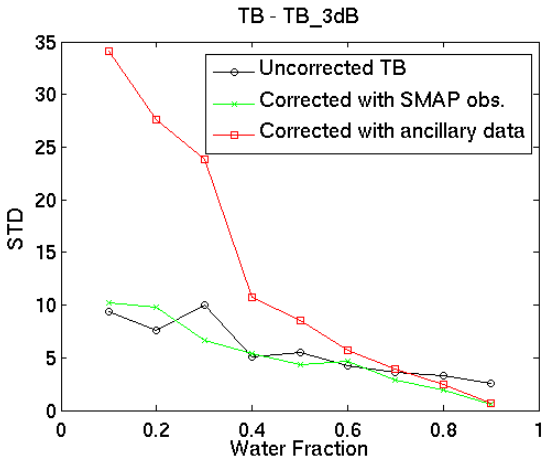
  First, we correct land temperature from water contamination using average contamination-free SMAP observations over water within 3x3 degrees cell containing the target point.

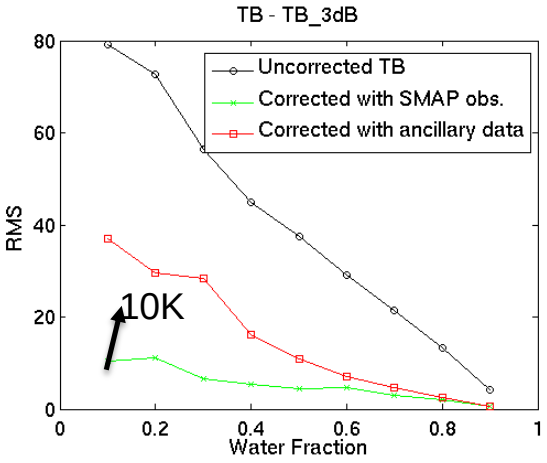
  Then, we correct the water temperature using average corrected land temperatures within 1x1 degree cell containing the target point.

Statistics Based on Simulations – Great Lakes

The use of SMAP observations shows much better performance over water





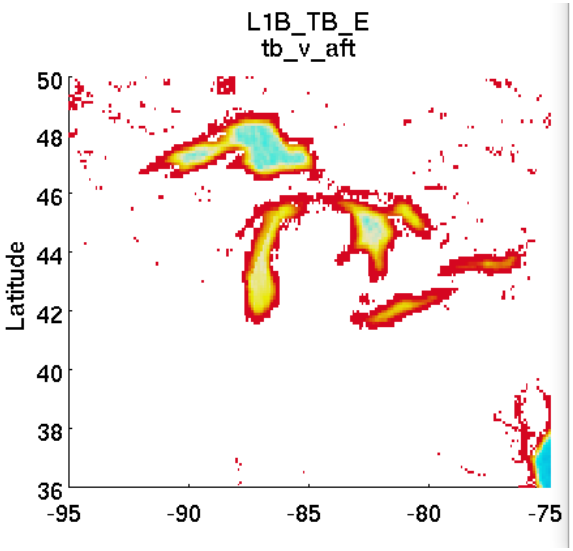


This area corresponds to small lakes. No enough data for stats

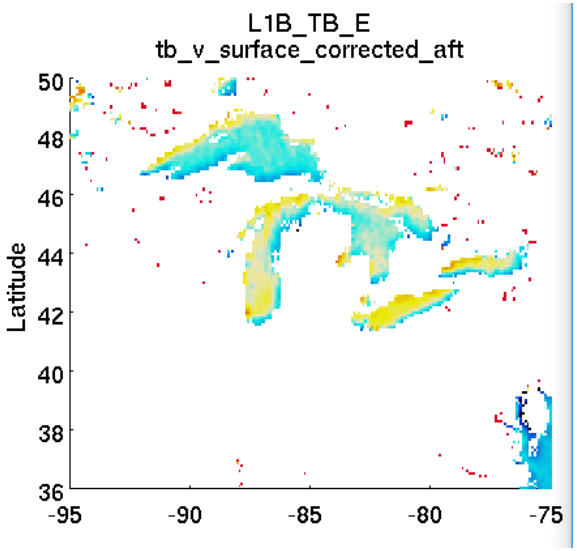
0=Land 1=Water

Real Data

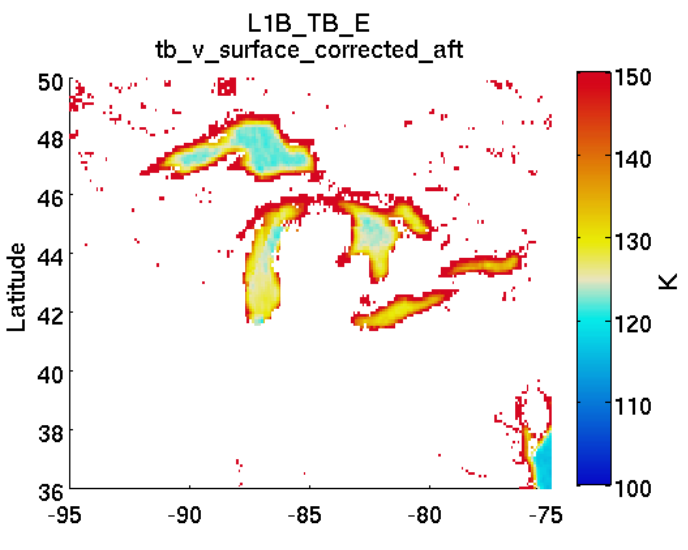
Uncorrected TB



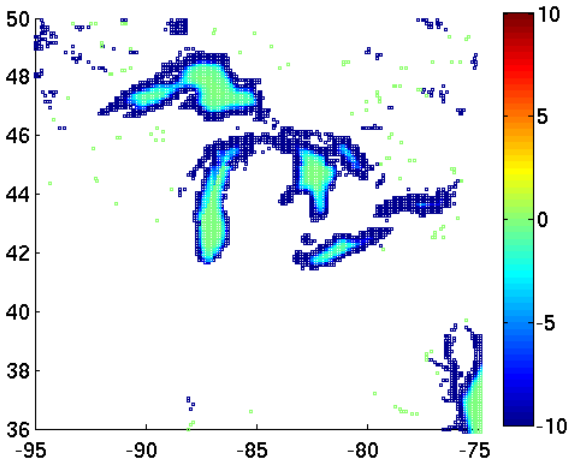
Corrected with SMAP obs.



Corrected with ancillary data

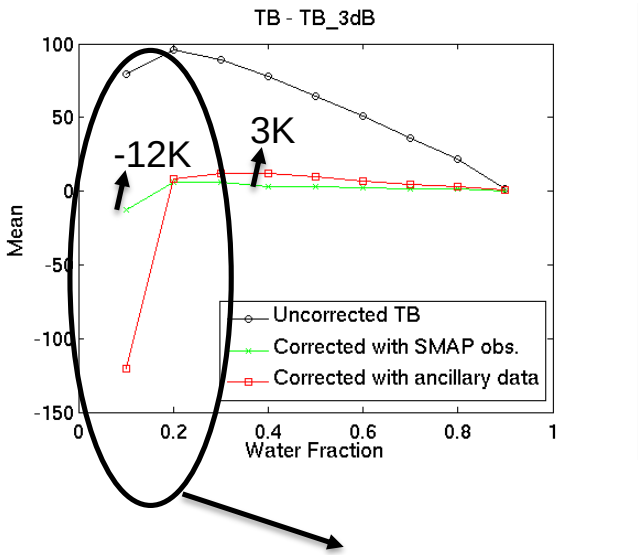


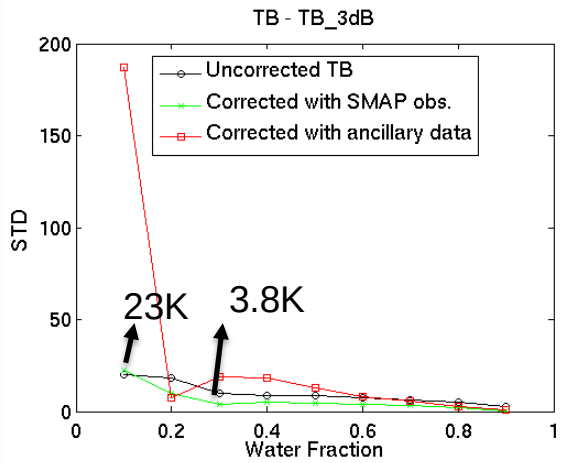
SMAP Obs. Correction – Ancillary data Correction

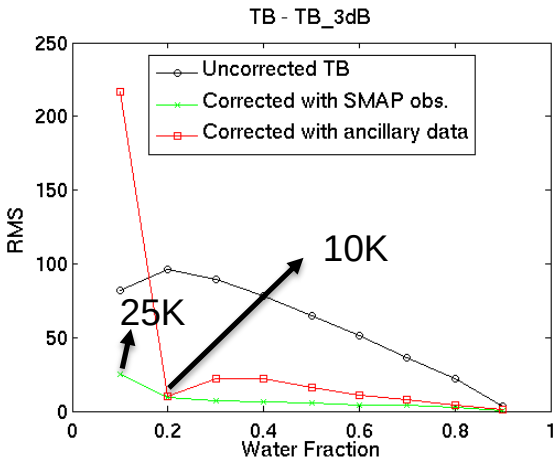


Statistics Based on Simulations – Yucatan

The use of SMAP observations shows much better performance over water





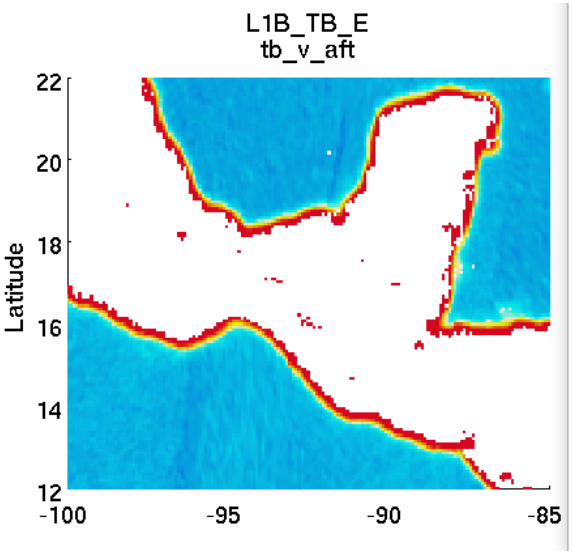


This area corresponds to small lakes. No enough data for stats

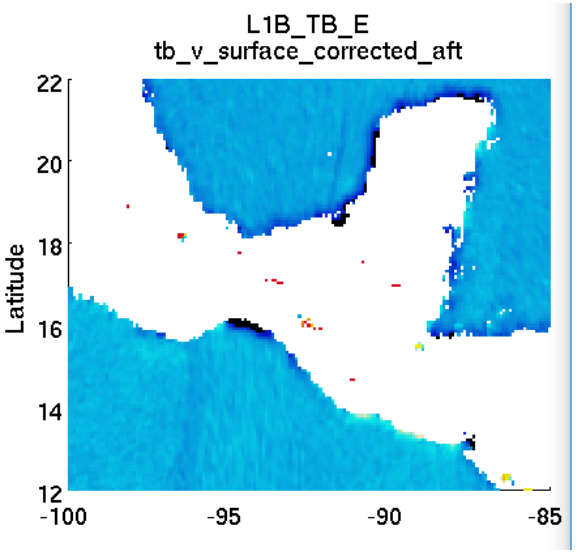
0=Land 1=Water

Real Data

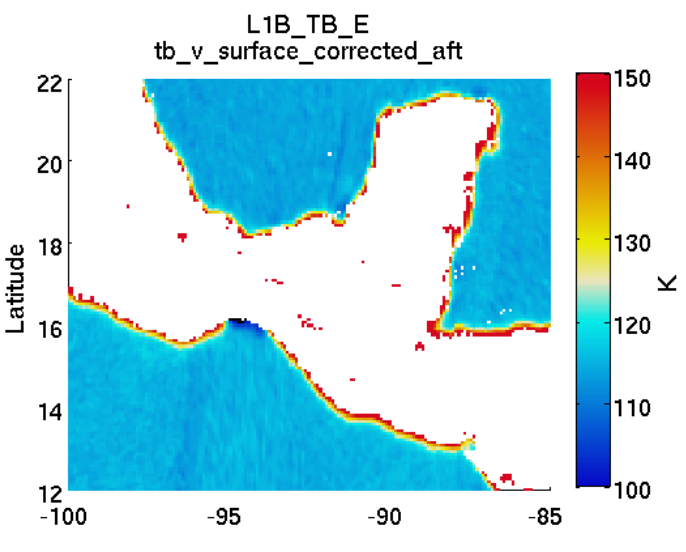
Uncorrected TB



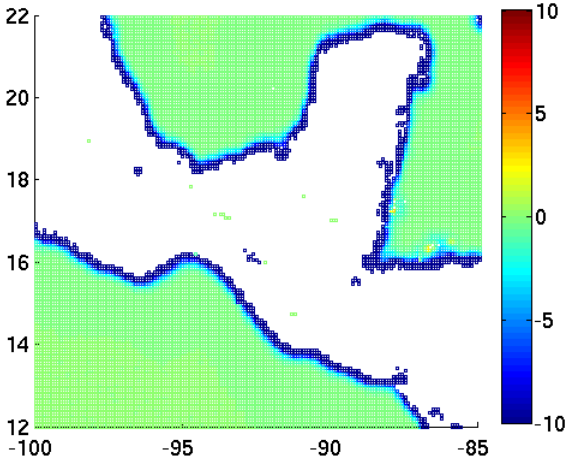
Corrected with SMAP obs.



Corrected with ancillary data

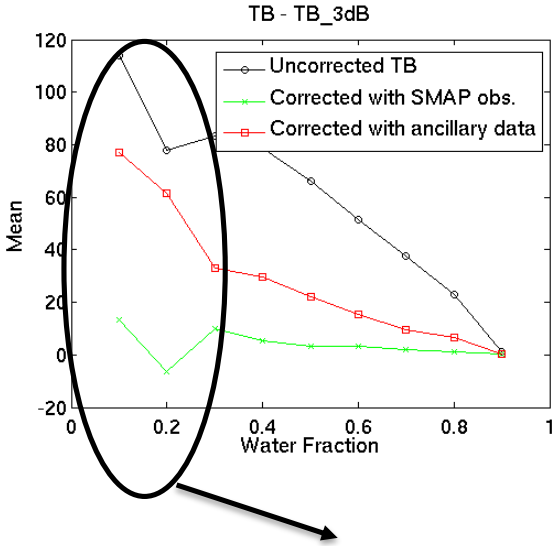


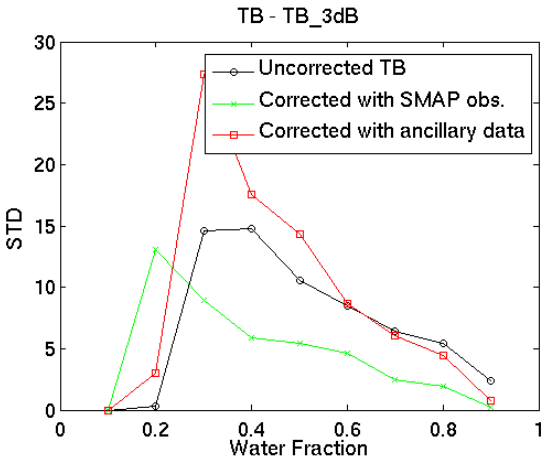
SMAP Obs. Correction – Ancillary data Correction

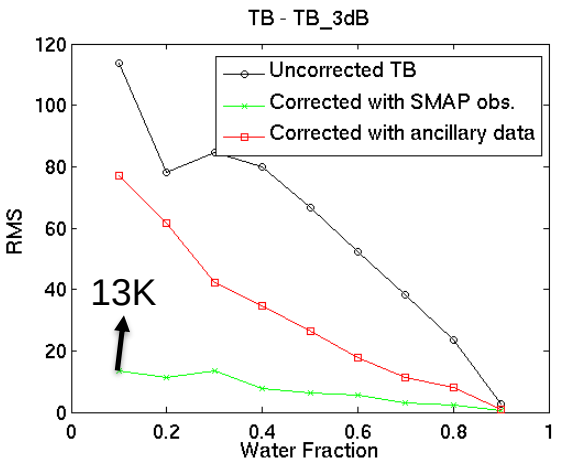


Statistics Based on Simulations – Madagascar

The use of SMAP observations shows much better performance over water





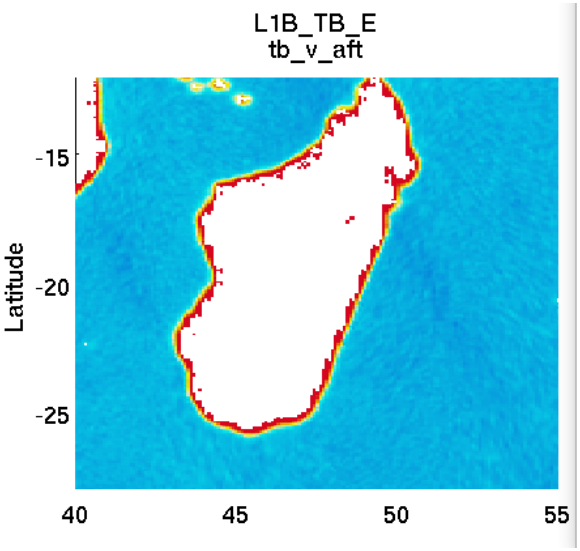


This area corresponds to small lakes. No enough data for stats

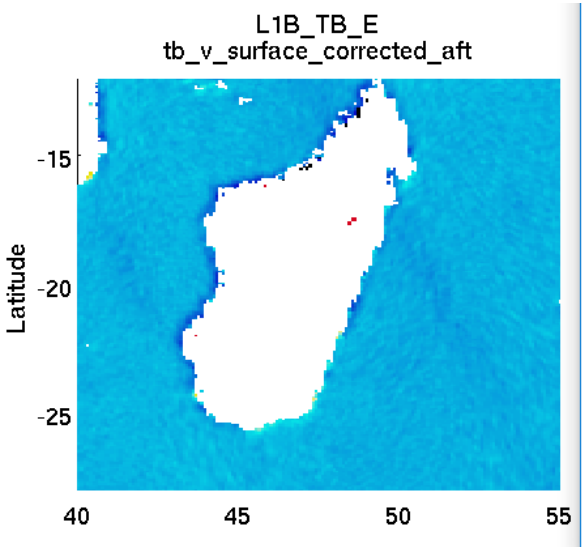
0=Land 1=Water

Real Data

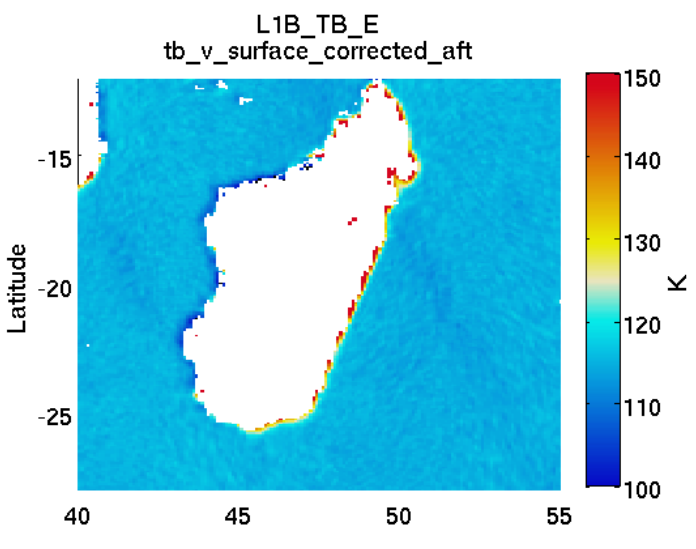
Uncorrected TB



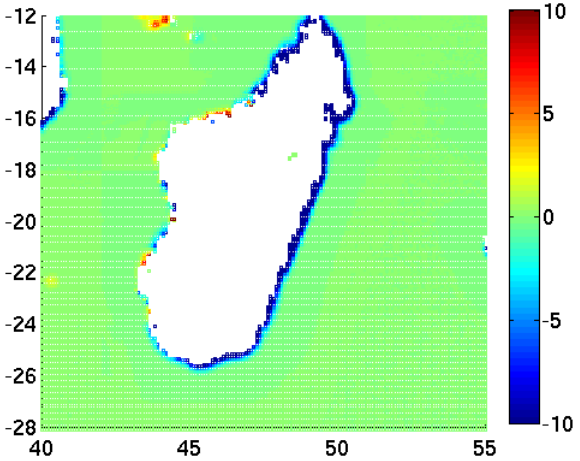
Corrected with SMAP obs.



Corrected with ancillary data



SMAP Obs. Correction – Ancillary data Correction



Asymmetry on Real Data

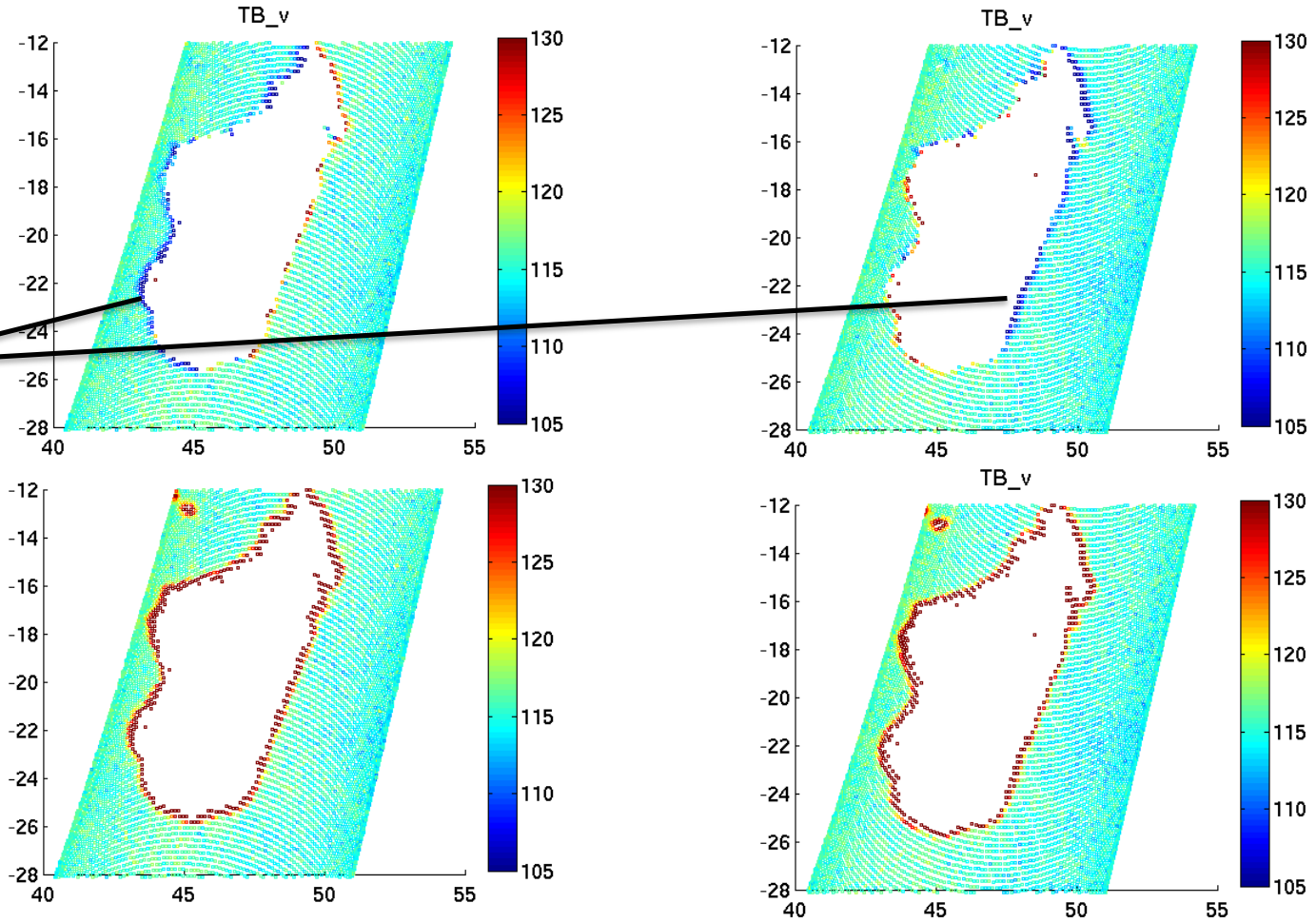
Descending – aft look

Descending – fore look

Corrected

Look direction dependence

Uncorrected



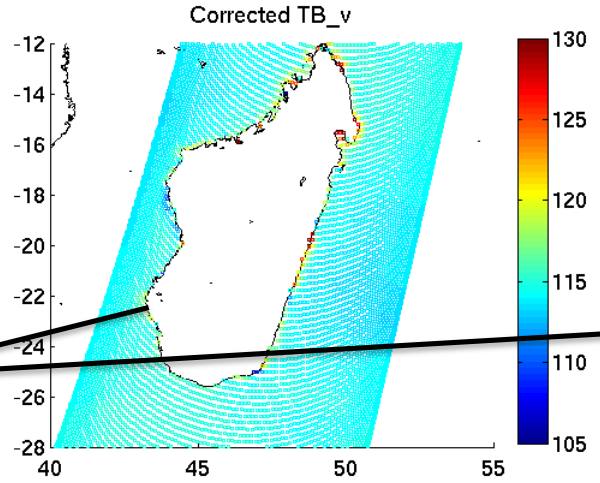
Could the asymmetry be caused by a residual pointing error?

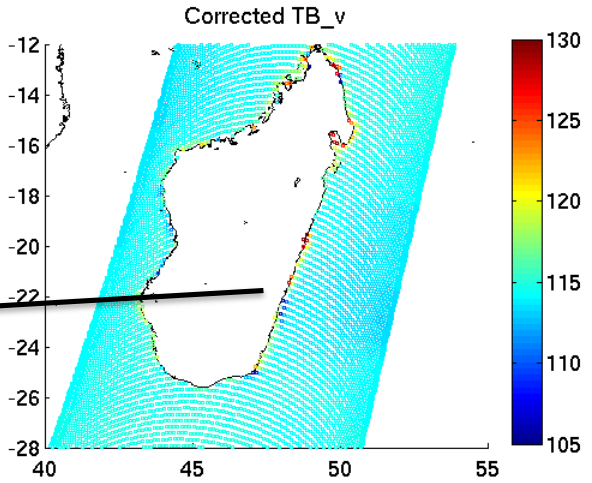
Go back to simulated data

Descending – aft look

Descending – fore look

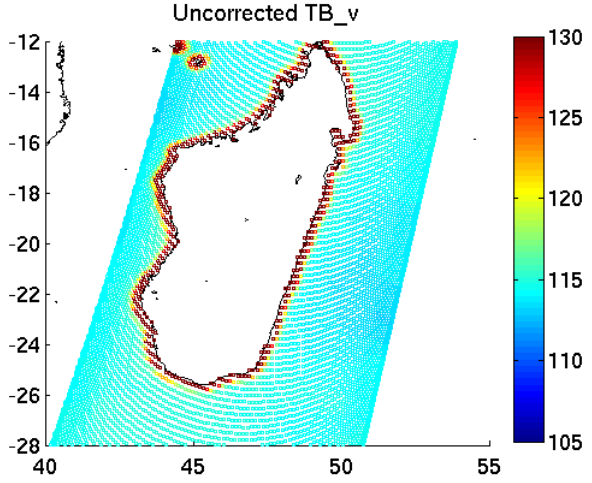
Corrected

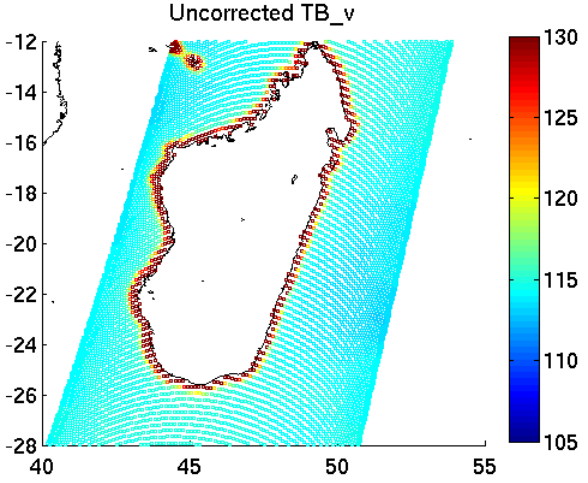




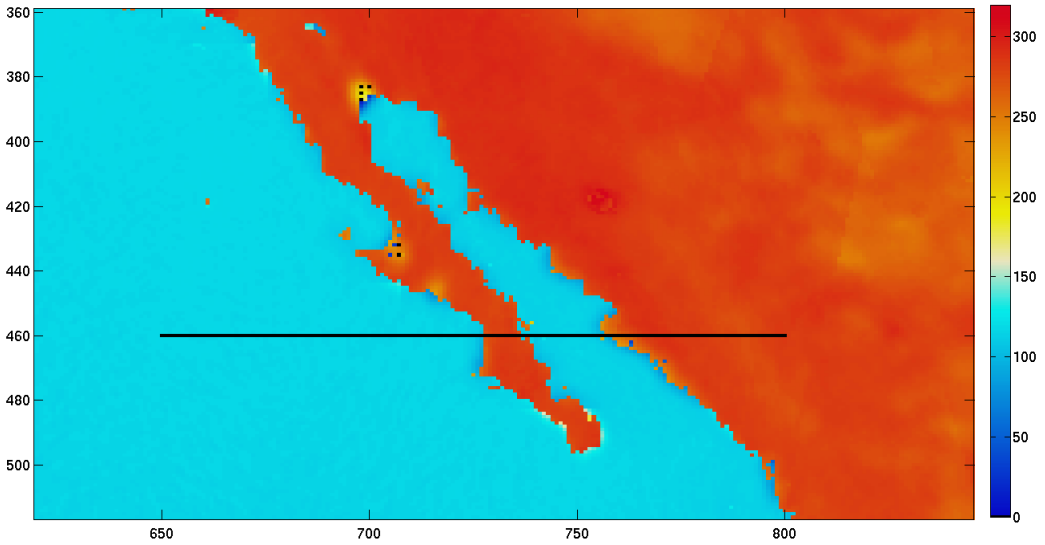
No asymmetry is observed

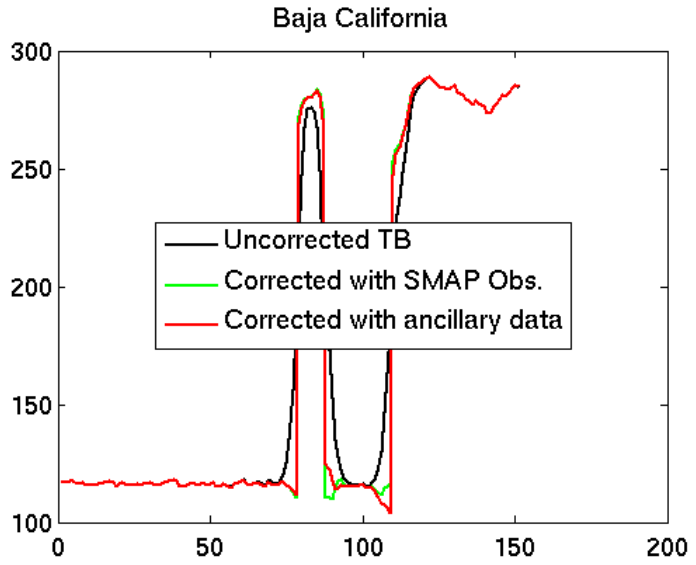
Uncorrected

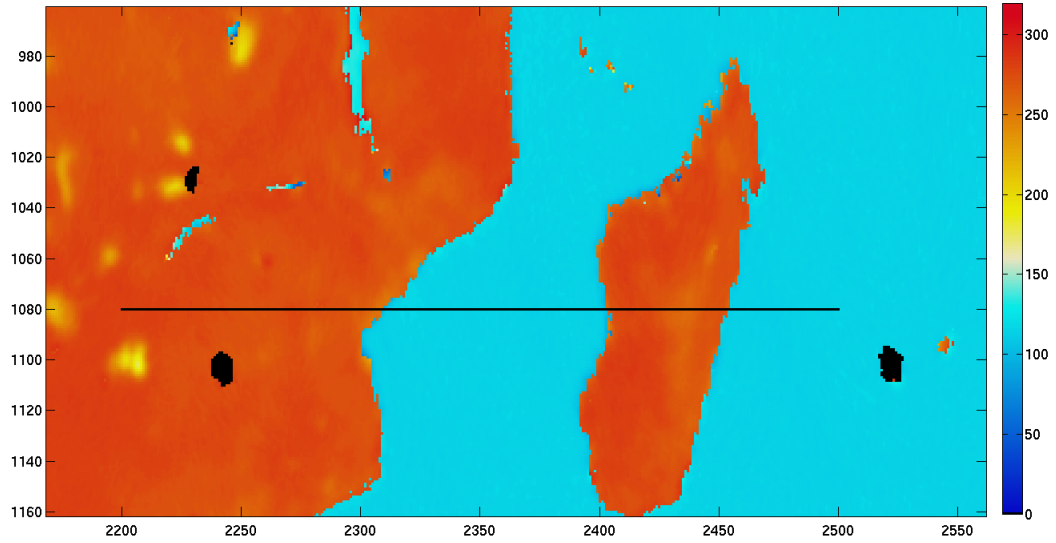


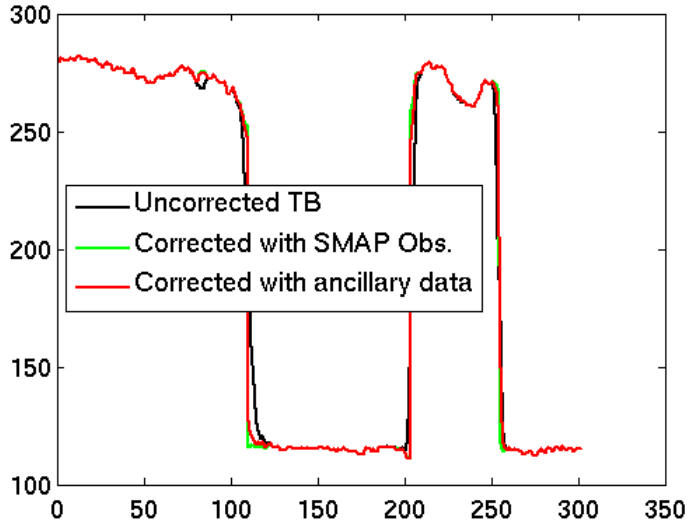


Cut View

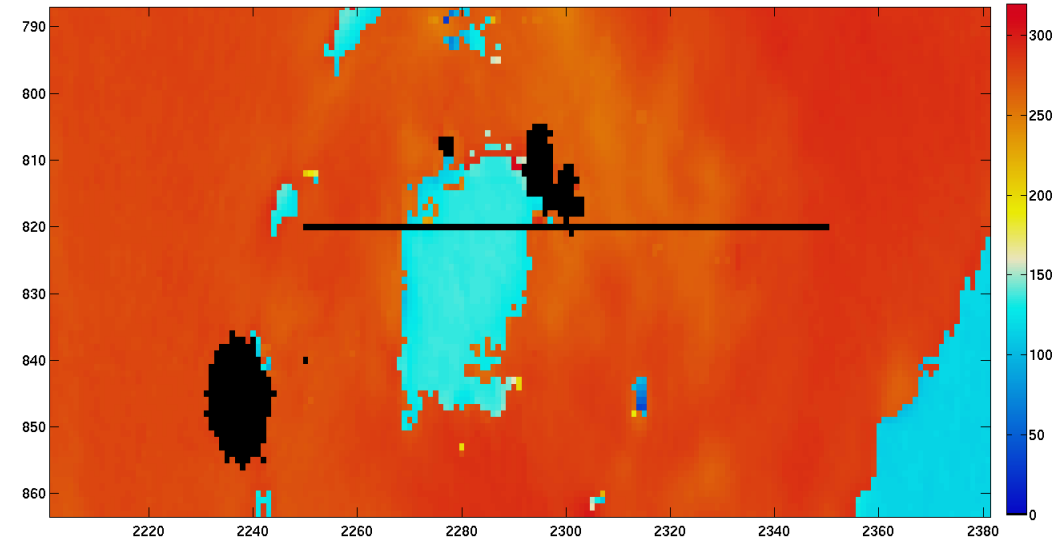

360
380
400
420
440
460
480
500
650
700
750
800
300
250
200
150
100
50
0

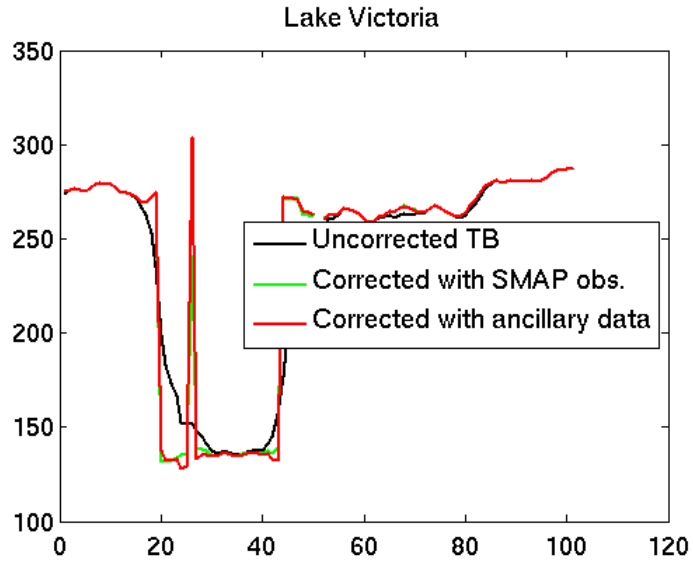

Baja California
300
250
200
150
100
0
50
100
150
200
Uncorrected TB
Corrected with SMAP Obs.
Corrected with ancillary data

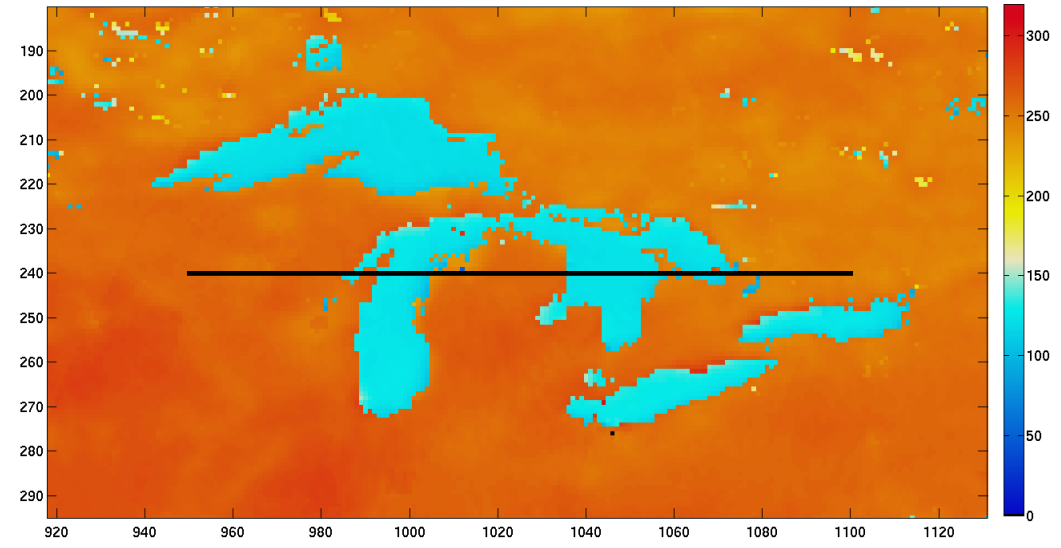

980
1000
1020
1040
1060
1080
1100
1120
1140
1160
2200
2250
2300
2350
2400
2450
2500
2550
300
250
200
150
100
50
0

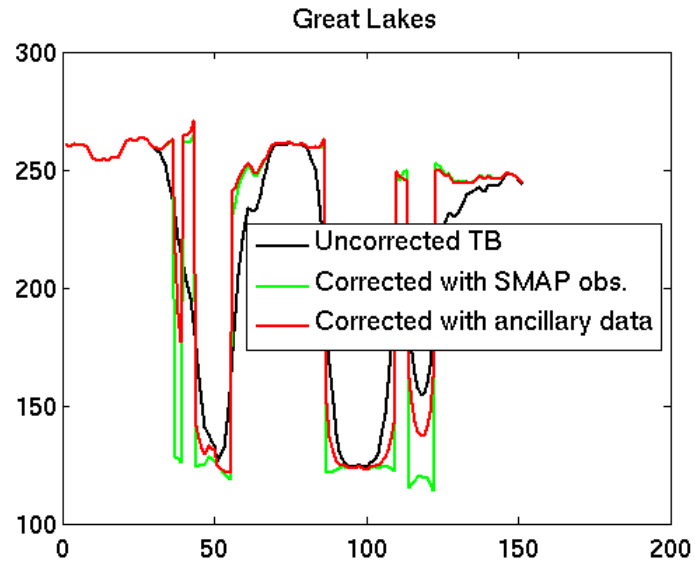

Madagascar
300
250
200
150
100
0
50
100
150
200
250
300
350
Uncorrected TB
Corrected with SMAP Obs.
Corrected with ancillary data

Cut View


790
800
810
820
830
840
850
860
2220
2240
2260
2280
2300
2320
2340
2360
2380
300
250
200
150
100
50
0


Lake Victoria
350
300
250
200
150
100
0
20
40
60
80
100
120
Uncorrected TB
Corrected with SMAP obs.
Corrected with ancillary data


190
200
210
220
230
240
250
260
270
280
290
920
940
960
980
1000
1020
1040
1060
1080
1100
1120
300
250
200
150
100
50
0


Great Lakes
300
250
200
150
100
0
50
100
150
200
Uncorrected TB
Corrected with SMAP obs.
Corrected with ancillary data

Conclusion

- Use of SMAP observation to correct land temperature shows no difference with respect to the use of ancillary data.
- Use of SMAP observation to correct Ocean temperature shows better performance with respect to the use of ancillary data.
- We recommend to use SMAP observation for correction.
- We are underestimating water temperatures after correction. Need to explore different approaches.
- We observe some asymmetry after correction. Need to be explore. Pointing error?

L1B_TB Product – New Elements Overview

New field	Description
footprint_surface_status	Indicates if the center of footprint lies on land (0) or water (1).
surface_water_fraction_mb_h	Gain weighted fraction of static water within the radiometer H pol antenna pattern
surface_water_fraction_mb_v	Gain weighted fraction of static water within the radiometer V pol antenna pattern
tb_h_surface_corrected	Water/land contamination corrected horizontally polarized brightness temperature at the surface after RFI filtering
tb_v_surface_corrected	Water/land contamination corrected vertically polarized brightness temperature at the surface after RFI filtering

Note that tb_h and tb_v were not eliminated.
surface_water_fraction_mb was replaced by surface_water_fraction_mb_v and surface_water_fraction_mb _h

L1B_TB_E Product – New Elements Overview

New filed	Description
grid_surface_status	Indicates if the grid point lies on land (0) or water (1)
surface_water_fraction_mb_h_aft	Gain weighted fraction of static water within the radiometer H pol antenna pattern for aft looks
surface_water_fraction_mb_h_fore	Gain weighted fraction of static water within the radiometer H pol antenna pattern for forward looks
surface_water_fraction_mb_v_aft	Gain weighted fraction of static water within the radiometer V pol antenna pattern for aft looks
surface_water_fraction_mb_v_fore	Gain weighted fraction of static water within the radiometer V pol antenna pattern for forward looks
tb_h_surface_corrected_aft	Water/land contamination corrected horizontally polarized brightness temperature at the surface after RFI filtering for aft looks
tb_h_surface_corrected_fore	Water/land contamination corrected horizontally polarized brightness temperature at the surface after RFI filtering for forward looks
tb_v_surface_corrected_aft	Water/land contamination corrected vertically polarized brightness temperature at the surface after RFI filtering for aft looks
tb_v_surface_corrected_fore	Water/land contamination corrected vertically polarized brightness temperature at the surface after RFI filtering for forward looks

Backup

L1B_TB_E Implementation

– If grid point is on land we apply the formula:

$$TB_p^{land} = \frac{TB_p - f * \overline{TB}_p^{water}}{1 - f}$$

– If grid point is on water we apply the formula:

$$TB_p^{water} = \frac{TB_p - (1 - f) * \overline{TB}_p^{land}}{f}$$

where *f* is the water fraction. *f*=1 in pure water and *f*=0 for pure land.

$f = \sum_{i=1}^{6} a_i f_i$ where a_i are the Backus Gilbert coefficients.